DOE/NETL
Mercury Control Technology R&D Project Summary

Project Title	DOE Funding	Lead Company / Participants	Start/End Dates	Project Description	Plant Site	Coal Rank	Results	Policy Issues
Full-Scale Testing of Mercury Control Via Sorbent Injection DE-FC26-00NT41005 Andrew O'Palko	$4,542,563	ADA-ES Participants include EPRI, EPA, Alabama Power Company, PG&E National Energy Group, and We Energies (subsidiary of Wisconsin Energy)	10/1/00 - 9/30/04	**Activated carbon injection** Full-scale field demonstration testing of powdered activated carbon injection at four power plants: Alabama Power's 270 MW E.C. Gaston Unit 3 that burns low sulfur bituminous coal and uses a hot-side ESP and COHPAC fabric filter for particulate control; Wisconsin Energy's 600 MW Pleasant Prairie Unit 2 that burns a Powder River Basin subbituminous coal and uses a cold-side ESP; PG&E NEG's Brayton Point Station that burns low sulfur bituminous coal and uses two cold-side ESPs in-series; and PG&E NEG's Salem Harbor Station that burns low sulfur bituminous coal, uses a cold-side ESP and also a SNCR system for NOx control.	Gaston	Bit.	Testing completed April 2001. Mercury capture based on three Ontario Hydro tests averaged from 87 to 90% with a carbon injection rate of 1.5 lbs/MMacf. However, the mercury S-CEM data indicated an average capture of 78% that varied from 36% to 90%. Average COHPAC inlet mercury concentration was approximately 11 µg/dncm, and 40% of it was elemental.	• The variation in capture efficiency was attributed to changing coal and operating conditions. For example, the COHPAC inlet mercury concentration ranged from approximately 5 to 20 µg/dncm. • There was no improvement in mercury capture using the spray-cooling system. • An undesired side effect of carbon injection was an increase in the required cleaning frequency of the COHPAC baghouse. • Representativeness: COHPAC operated at approximately 270 °F which is significantly different than most fabric filter systems and may have enhanced mercury removed. The air-to-cloth ratio was relatively high (8:1) and a larger fabric filter may have improved performance albeit at a higher cost.
					Pleasant Prairie	PRB	Testing completed Nov. 2001. Norit's Darco FGD activated carbon was used during the three 5-day long-term tests at feed rates of 1.6, 3.7, and 11.3 lb/MMacf. Mercury capture averaged approximately 46%, 57%, and 66%, respectively. Average ESP inlet mercury concentration was approximately 17 µg/dncm, and 85% of it was elemental.	• The carbon injection did not deteriorate ESP performance. However, the ESP is relatively large (468 SCA) and additional testing needs to be conducted on other units with smaller ESPs to evaluate possible degradation of particulate collection efficiency. • There was no improvement in mercury capture using the spray cooling system. • The PAC injection rendered the fly ash unacceptable for marketing as a concrete additive. This could dramatically affect the cost of removal as well as create a new waste stream. • Representativeness: The CSESP at existing coal plants has a median SCA of 300. The SCA for the demonstration is about 50% larger than is typically observed for existing plants.
					Brayton Point	Bit.	Testing completed Aug. 2002. The PAC injection was located between the first and second cold-side ESPs. Average mercury concentration at the inlet to the first ESP was approx. 6 ug/dncm of which 85% was particulate-bound. During baseline testing the average mercury removal ranged from 30 to 90% across both ESPs and 0 to 10% across the second ESP. During the parametric testing of Norit's Darco FGD activated carbon at feed rates of 3, 7, 10, 15, and 20 lb./MMacf the mercury capture averaged approx. 25%, 40%, 70%, 75%, and 90% respectively across the second ESP.	• The carbon injection did not deteriorate ESP performance. However, the second ESP is relatively large (400 SCA). • Representativeness: The demonstrated ESP configuration is unusual and could affect mercury removal. Oxidized fraction of mercury is higher than typically observed.
					Salem Harbor	Bit.	Testing completed Nov. 2002. Average mercury concentration at the inlet to the ESP was approx. 10 ug/dncm of which 95% was particulate-bound. During baseline testing without PAC injection, average mercury capture was approximately 90%. The high baseline mercury removal is attributed to high levels of unburned carbon (LOI was 25 to 30%) and low flue gas temperature (approx. 270°F). Baseline mercury removal decreased from approx. 90% to 20% while increasing flue gas temperature from 270 to 350°F. A maximum mercury capture of only 45% was achieved at 350 °F with activated carbon injection.	• Increasing flue gas temperature decreased mercury capture during baseline testing without AC injection. • The NOx SNCR system had no effect on mercury capture. • Representativeness: particulate fraction of mercury is extremely high and is well beyond normally observed levels. Loss on ignition was typically 25% to 30% and is an order of magnitude higher than typical levels.

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Full-Scale Testing of Enhanced Mercury Control in Wet FGD DE-FC26-00NT41006 Bruce Lani	$1,305,374	Babcock & Wilcox and McDermott Technology, Inc. (B&W/MTI) Project team includes the Ohio Coal Development Office, Michigan South Central Power Agency (MSCPA), and Cinergy.	9/27/00 - 9/30/02	**Wet FGD reagent** Full-scale field testing of a proprietary liquid reagent to enhance mercury capture in two coal-fired power plants equipped with wet FGD systems. The testing was conducted at Michigan South Central Power Agency's 60 MW Endicott Station and Cinergy's 1300 MW Zimmer Station. Both plants burn Ohio high sulfur bituminous coal and use cold-side ESPs for particulate control. The Endicott Station utilizes a limestone wet FGD system with in-situ forced oxidation; while the Zimmer Station utilizes a magnesium enhanced lime wet FGD system with ex-situ forced oxidation.	Endicott	Bit.	Testing completed in 2001. Testing demonstrated the reagent was able to suppress mercury reduction across the wet FGD system. There was no increase in elemental mercury emissions during reagent usage compared to the baseline increase of over 40%. As a result, total mercury removal averaged 76% during the two-week verification testing compared to the baseline removal of approximately 60%. There was no significant change in the level of oxidized mercury removal which averaged over 90% both with and without reagent usage. % Hg Removal Species / Baseline / Reagent Total: 60% / 76% Oxidized: 90% / 93% Elemental: (40%) / 20%	• FGD mercury capture can be enhanced with the B&W/MTI proprietary reagent, but not necessarily in all applications (refer to Zimmer test results below). • The testing at Endicott and Zimmer also included an evaluation of the mercury concentration in the various by-product streams. One of the most significant findings from the test program was that the mercury in the wet FGD waste slurry from both plants was associated primarily with the fines and not bound to the gypsum particles. Therefore, it may be possible to use particle separation techniques to minimize potential mercury contamination of the gypsum. • Representativeness: The demonstration configuration is typical of existing wet scrubber systems.
					Zimmer	Bit.	Testing completed in 2001. The reagent testing did not achieve the desired effect. Reduction of oxidized mercury to elemental mercury continued across the wet FGD system during reagent usage. Elemental mercury increased by 41% across the wet FGD system during reagent usage compared to the baseline increase of approximately 20%. There was no significant effect on total mercury removal, which averaged 51% during the two-week verification testing compared to a baseline removal of approximately 45%. The reagent had no significant impact on the level of oxidized mercury removal, which averaged 87% during reagent injection. % Hg Removal Species / Baseline / Reagent Total: 45% / 51% Oxidized: 90% / 87% Elemental: (20%) / (41%)	• Test results indicate that oxidation reagent performance may be dependent on operational characteristics of the wet FGD system. Possible explanations for the poor results at Zimmer include the much higher sulfite concentration and lower liquid-to-gas ratio in the magnesium enhanced lime wet FGD system, which may have impeded the reagent performance. (Note: Endicott uses a limestone wet FGD.)
Pilot Plant Study of Low Temperature Mercury Capture with an ESP DE-FC26-01NT41181 Lynn Brickett	$1,826,539	CONSOL The project team includes Allegheny Energy, Alstom Power Inc., Environmental Elements Corp., and Carmeuse North America.	8/31/01 - 9/3/04	**Novel process** Pilot-scale testing to evaluate the effect of flue gas temperature on mercury capture in plants equipped with ESPs. The testing is being conducted at Allegheny Energy's 288 MW Mitchell Power Station, Unit No. 3 that burns a medium sulfur, eastern bituminous coal and is equipped with an ESP and wet FGD. The pilot plant consists of an air preheater to lower flue gas temperature, a water-spray cooling system as an optional method to lower flue gas temperature, an ESP to collect the mercury along with the fly ash, and an alkaline sorbent (magnesium hydroxide) injection system to control sulfuric acid condensation.	Mitchell	Bit.	Parametric testing completed and long-term testing started in Summer 2004. Average mercury removal of 50% across ESP achieved during parametric testing at a temperature of 225°F.	• Low temperature operation offers potential low cost enhancement for co-benefit mercury capture by cold-side ESP.

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Assessment of Low Cost Novel Mercury Sorbents DE-FC26-01NT41180 Bob Patton	$550,654	Apogee The project team includes EPRI, URS, Illinois State Geological Survey, ADA Environmental Solutions, Physical Sciences Inc., We Energies, and Midwest Generation.	8/2/01 - 8/1/03	**Alternative sorbents** This project will assess the mercury capture performance of several low-cost novel mercury sorbents using an actual flue gas slipstream in a small-scale pilot plant equipped with an ESP and baghouse. The pilot testing is being conducted at two power plants, Wisconsin Electric Power's Valley Plant that burns a low sulfur bituminous coal and Midwest Generation's Powerton Generating Station that burns a Powder River Basin sub-bituminous coal. The sorbents being tested include activated carbon samples from coal, biomass, and tires; char sorbents made from coal; fly ash-derived sorbents; and zeolite sorbents.	Powerton	PRB	The Powerton slipstream pilot testing included experimental sorbents produced from corn (CFA), oil soot (CS80), waste tires (TDAC), flyash (STI-B), a commercially available carbon made from lignite coal (HOK), and an iodine-impregnated sorbent (CB-IAC). Norit's Darco FGD activated carbon was also tested as a benchmark. Major results from the Powerton pilot testing are as follows: • Initial screening tests were conducted at 1.5 lb/MMacf and 300°F using the COHPAC configuration. Similar mercury removal of approximately 80% was achieved by the FGD, CFA, CS80, and HOK sorbents. Mercury removal for the TDAC and STI-B were approximately 60% and 35% respectively. The CB-IAC mercury removal was 72% at a lower injection rate of 0.6 lb/MMacf. The CFA and HOK sorbents were selected for additional parametric testing in the COHPAC configuration based on their lower estimated delivered cost. • The parametric and long-term COHPAC testing again showed similar performance of the CFA, HOK, and FGD sorbents. However, mercury removal was different for the two types of filter bag materials that were tested. At 2 lb/MMacf the three sorbents achieved approximately 90% mercury removal with the Teflon glass bag, but only 70 - 80% mercury removal with the Torcon bag. However, the difference in mercury removal may have been a result of the bag cleaning frequency used during the testing. Mercury removal was also similar for the three sorbents at both 300° and 350° F. • Based on results of the COHPAC screening tests, the CFA and CS80 were selected for testing in the residence chamber (ESP) configuration. The FGD and IAC sorbents were also included as benchmarks. The CFA, CS80, and FGD mercury removal was less than 50% for injection rates between 2.5 and 15 lb/MMacf at both two and four second residence times. The IAC sorbent achieved approximately 60% mercury removal at four seconds and 45% at two seconds at 2.5 lb/MMacf. • Preliminary cost estimates for the alternative sorbents indicate production costs could be approximately 50% less than commercially available activated carbons.	• Lower cost alternative sorbents could be capable of similar mercury removal performance compared to commercially available activated carbons in PRB coal applications. • Representativeness: Technique may be sensitive to flue gas chemistry and flue gas control equipment configuration.
					Valley	Bit.	Long-term testing at Valley was conducted in the TOXECON configuration for 48 hours at a targeted injection rate of 2 lb/MMacf for the three sorbents (A10, CFA, and Darco FGD) and a temperature of 315°F. In addition, two filter bag materials were evaluated: a 2.7-denier PPS (Ryton) felt bag, and a 7.0-denier PPS felt Torcon bag. The mercury removal across the bags increased for approximately 2 to 12 hours before leveling off at approximately 93% to 95% for the Torcon bag and 94% to 99% for the Ryton bag. The two, low cost sorbents (A10 and CFA) were able to achieve maximum mercury removal efficiencies faster than the Darco FGD with comparable sorbent feed rate and mercury capture performance.	• See above comments for Powerton.

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Mercury Control with the Advanced Hybrid Particulate Collector DE-FC26-01NT41184 Bill Aljoe	$2,641,120	UND/EERC The project team includes W.L. Gore & Associates and Otter Tail Power Company.	6/27/01 - 12/31/04	**Novel process** Conduct bench-scale, small pilot-scale, and large pilot-scale field testing to evaluate the mercury control performance of sorbent injection used in conjunction with the Advanced Hybrid Particulate Collector (AHPC). AHPC is a combination ESP and fabric filter designed to optimize fine particulate collection. Bench-scale and small pilot-scale testing is being conducted at EERC. Field demonstration pilot plant testing is being conducted at Otter Tail Power Company's 450 MW Big Stone Plant that burns Powder River Basin sub-bituminous coal.	Big Stone	PRB	• Results from the November 2001 short-term AHPC 2.5 MW pilot-plant test at Big Stone indicated 91% total mercury collection efficiency with a sorbent feed rate of 1.5 lb/million acf compared to a baseline (no sorbent) mercury collection efficiency of 49%. The relatively high mercury removal rates may have occurred because the average inlet mercury speciation during the testing was 55.4% particulate, 38.1% oxidized, and only 6.4% elemental. This is not considered typical for PRB coal, which normally have much higher levels of elemental mercury. Subsequent analysis showed that the high proportion of particulate and oxidized mercury may have been related to unexpectedly high levels of chlorine in the flue gas, which may have resulted from co-combustion of tire-derived fuel (TDF) during the November 2001 test period. • A second AHPC 2.5 MW pilot-plant test was conducted at Big Stone in August 2002 using a Belle Ayr PRB coal. Mercury speciation was 17% particulate, 32% oxidized, and 51% elemental. Baseline mercury removal ranged from 0% to 10%. Mercury removal was 63% during activated carbon injection at 1.5 lb/MMacf and without any TDF co-firing, and up to 88% at TDF injection rates of 150 to 177 tons per day. There was no adverse effect on AHPC particulate collection performance during the activated carbon injection testing. • A third AHPC 2.5 MW pilot-plant test was conducted at Big Stone in November 2002. Mercury removal ranged from 65% to over 90% during activated carbon injection at 1.5 lb/MMacf and TDF co-firing rates varying from 0 to 250 tons per day (average 33.5 tpd). A possible reason for the improved mercury removal in November compared to the August 2002 test is lower flue gas temperature of 250° F compared to 270° - 290°F. Supplemental injection of HCl had little or no effect on mercury removal. • A small AHPC 200 acfm pilot-scale test was conducted in late 2002 using a Springfield high-sulfur bituminous coal. The NORIT Darco FGD activated carbon was ineffective with average mercury removal at less than 15% for various combinations of flue gas temperature (275° - 320°F) and injection rates. A possible reason for the poor mercury removal was the relatively high level of SO_3 (over 30 ppm) concentration in the flue gas. • A one-week AHPC 200 acfm pilot-scale test was conducted, in which, the PRB feed rate and the TDF feed rate were precisely controlled. In addition, the Darco FGD feed rate was held constant at 1.5 lbs/MMacf during this experiment. While burning 100% PRB, the oxidized mercury level was 19%, and mercury capture ranged from 48% to 78%. Burning 5% TDF on a mass basis resulted in 47% oxidized mercury and 88% mercury removal. Burning 10% TDF on a mass basis resulted in 85% oxidized mercury and 95% mercury removal. • Another one-month field test was completed during May-June 2003 with the 2.5 MW AHPC at Big Stone. Under baseline conditions, mercury removal ranged from 0% to 30% with elemental mercury levels of 20% to 70%. Mercury capture of 65% to 95% was observed with Darco FGD feed rates ranging from 1 to 3 lbs/MMacf. The overall mercury removal with the AHPC was similar to a baghouse or COHPAC under these conditions.	• Activated carbon injection at 1.5 lb/MMacf with the AHPC in PRB coal application can achieve from 63% to 90% mercury removal depending on flue gas temperature. • However, activated carbon injection in conjunction with the AHPC may be ineffective in high-sulfur bituminous coal-fired applications. • Higher baseline mercury capture was reported during TDF cofiring, which resulted in higher HCl concentrations. • Representativeness: Scale-up of the results from demonstration must be reconciled based on past experience with flue gas control technology of trace species.

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Mercury Removal in a Non-Thermal, Plasma-Based Multi-Pollutant Control Technology for Utility Boilers DE-FC26-01NT41182 Lynn Brickett	$2,248,002	Powerspan The project team includes FirstEnergy.	9/28/01 - 6/30/04	**Novel process** Conduct pilot-scale field-testing to optimize mercury control performance of the Electro-catalytic oxidation (ECO) process. ECO is a non-thermal, plasma-based multipollutant control concept designed for the simultaneous removal of SO_2, NOx, and fine particulate emissions. The process includes a dielectric barrier discharge (DBD) reactor to oxidize SO_2, NOx, and mercury for subsequent removal in an ammonia-based reagent wet FGD system, which produces ammonium sulfate/nitrate fertilizer as a by-product. Fine particulate and aerosols are captured in a wet ESP. The testing is being conducted at FirstEnergy's R.E. Burger Plant that burns eastern bituminous coal.	R.E. Burger	Bit.	The testing was completed in 2003 and a final report is being prepared. • Normal inlet flue gas elemental mercury concentration is extremely low at the Burger Plant and artificial injection of elemental mercury into the pilot plant was tested to demonstrate ECO capability to capture elemental mercury. However, the injected elemental mercury was naturally oxidized in the flue gas prior to entering the DBD reactor. Therefore, the ability of the DBD reactor to oxidize mercury could not be demonstrated. • Preliminary Ontario Hydro method test measurements in May 2002 resulted in an average mercury removal of 88% across the ECO pilot plant. • Mercury captured in the ECO ammonia scrubber liquid is removed using a sulfur-impregnated activated carbon filter (Mersorb). Mercury levels in the scrubber liquid have been reduced from 200 ppb to less than the limit of detection (approx. 20 ppb).	• While particulate and oxidized mercury removal exceeded 95%, there was some apparent reduction of oxidized mercury to elemental mercury within the wet FGD system. • The potential elemental mercury capture of the ECO technology could not be demonstrated due to naturally high levels of mercury oxidation at the test site. • Representativeness: Scale-up of the results from demonstration must be reconciled based on past experience with flue gas control technology of trace species.

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Testing of Mercury Control with Calcium-Based Sorbents and Oxidizing Agents DE-FC26-01NT41183 Barbara Carney	$1,109,719	Southern Research Institute (SRI) The project team includes ARCADIS G&M.	9/5/01 - 9/4/04	**Alternative sorbents** Conduct bench-scale and pilot-scale testing to assess the mercury capture performance of calcium-based sorbents and oxidizing agents as an alternative to commercially available activated carbons. ARCADIS has developed two proprietary calcium-based sorbents that could provide for the simultaneous removal of both mercury and SO_2 from coal-fired power plants. One sorbent consists of a hydrated lime, $Ca(OH)_2$, with an oxidant and the other sorbent consists of a silica-modified calcium, $CaSiO_3$, with an oxidant. The oxidant is intended to enhance overall sorbent mercury capture by oxidizing gas-phase elemental mercury. Other calcium-based sorbents such as lime will be used with alternative oxidants such as injected chlorine compounds, sodium tetra-sulfide, or high iron oxide fly ash from the bituminuous coal. These oxidants will be tested with a lime sorbent on a subbituminous Powder River Basin coal that characteristically has a high fraction of elemental mercury.	Laboratory pilot test	various	• Overall results to date indicate the importance of sufficient levels of unburned carbon (UBC) to promote the oxidation and capture of mercury using calcium-based sorbents for both bituminous and subbituminous coal flue gases. As a result, future testing is to focus on development of combined calcium-carbon sorbents. • The initial pilot-plant testing of two proprietary calcium-based sorbents with an oxidant additive and a bituminous coal showed both to be ineffective in enhancing the oxidation and capture of elemental mercury and achieved overall mercury removal of only 25 to 50%. Follow-up testing with an ordinary hydrated lime sorbent without the oxidant was able to remove 80 to 90% of the mercury which occurred primarily across the sorbent dust cake collecting on the baghouse filter bags. Approximately 30 to 35% mercury capture occurred "in-flight" prior to the baghouse. • SRI and PS Analytical developed a "spike and recovery" system to reduce mercury S-CEM measurement uncertainty. A known concentration mercury "spike" is introduced in the sampling probe in order to increase the concentration of mercury in the sampled flue gas. • Pilot-scale testing with a kaolinite ($Al_2O_3.2SiO_2.H_2O$) adsorbent and a Choctaw bituminous coal was ineffective for mercury capture at injection temperatures that ranged from 1100° to 2100°F. • SRI conducted pilot-scale testing of chlorine gas (Cl_2) injection in order to evaluate the ability of HCl to promote mercury oxidation and adsorption with PRB coal ash. Chlorine injection through the burner was effective in increasing the oxidized mercury from less than 20% to over 50% and increasing mercury adsorption on the PRB coal ash from less than 5% to over 30%. However, chlorine injection upstream of the air heater was ineffective. • SRI conducted pilot-scale testing to condition PRB coal with a high-iron, low-chlorine bituminous coal. As a result, PRB coal ash composition was found to be more important than flue gas chlorine content relative to mercury oxidation and capture. With PRB coal only, there was less than 15% oxidized mercury at the baghouse inlet. However, a coal blend with 10% bituminous and 90% PRB coal resulted in greater than 50% oxidized mercury at the baghouse inlet. • SRI also conducted tests to condition the PRB coal ash with injection of high-iron bituminous coal ash and hydrated lime at the baghouse inlet. The rate of ash/lime injection was approximately equivalent to the PRB ash loading. Three ash/lime injection ratios were tested: 100% ash; 50% ash/ 50% lime; and 20% ash/ 80% lime. The mercury oxidation across the baghouse increased from a baseline of approximately 60% to 80% with 100% high-iron bituminous ash injection. The increase in mercury oxidation was less with the ash/lime blends. • Increasing the baghouse inlet flue gas temperature from 260° to 300°F increased oxidized mercury while burning 100% PRB coal. The oxidized mercury increased less than 10 percentage points at the baghouse inlet, but increased approximately 30 percentage points at the baghouse outlet. However, this temperature effect was not significant with the bituminous/PRB coal blend. • The mercury removal efficiency of activated carbon (NORIT FGD), carbon black, hydrated lime, and several designer calcium-carbon sorbents were compared in a catalyst test facility (CTF) at SRI across a temperature range from 300°F to 1100°F. o Activated carbon removed approx. 90% mercury from 300°F to 500°F, but was less effective at higher temperatures. o Carbon black was less effective than activated carbon and >90% of carbon black was consumed at higher temperatures. o Hydrated lime was ineffective at all temperatures. o Calcium-carbon sorbents provided the best mercury capture at 700°F. The sorbent with a higher percentage of carbon (i.e., 10%) was more effective than the lower-	• Both carbon and chlorine levels are important to promote the oxidation and capture of mercury in PRB coal applications. • The mercury capture effectiveness for PRB coals might also be enhanced using either a chlorine-based additive to the furnace, or fuel blending with high-iron bituminous coal. However, additional evaluation is necessary. • Representativeness: Scale-up of the results from demonstration must be reconciled based on past experience with flue gas control technology of trace species.

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Pilot Testing of Mercury Oxidation Catalysts DE-FC26-01NT41185 Bruce Lani	$897,616	URS Corporation The project team includes EPRI, Great River Energy (GRE), City Public Service (CPS) of San Antonio, and the North Dakota Industrial Commission.	8/30/01 - 8/29/04	**Oxidation catalyst** Conduct pilot testing to evaluate the performance of several catalyst materials to promote the oxidation of elemental mercury in the combustion flue gas. Increasing gas-phase oxidized mercury would enhance overall mercury capture in plants equipped with wet FGD systems. The pilot testing is being conducted at two power plants, Great River Energy's Coal Creek Station that burns a North Dakota lignite fuel and City Public Service (CPS) of San Antonio's J.K. Spruce Plant that burns a Powder River Basin (PRB) sub-bituminous fuel. The four catalysts being tested at Coal Creek are 1) Pd #1, a commercial palladium catalyst; 2) SCR, a Siemens commercial NOx catalyst using titanium-vanadium; 3) Carbon #6, a tire-derived activated carbon; and 4) SBA #5, an active fly ash. At J.K. Spruce the SBA #5 catalyst was replaced with a gold catalyst.	Coal Creek	Lignite	• Mercury concentration after the ESP varies from 13 to 18 µg/Nm^3 with approx. 15% oxidized. • Pilot testing for the Pd #1 and SCR catalysts began in October 2002. Testing of the SBA #5 catalyst began in December 2002. The Carbon #6 catalyst testing began in June 2003. • After 18 months, oxidation of elemental mercury across Pd #1 decreased from 90% to 65%. • After 10 months, oxidation across Carbon #6 decreased from 95% to 85%. • After 18 months, oxidation across SCR decreased from 67% to 30%. • After 16 months, oxidation across SBA #5 decreased from 75% to 30%. • There was some concern that the catalysts might also lead to oxidation of SO_2 and NO which could produce undesirable balance-of-plant effects. However, there is no apparent oxidation of SO_2 to SO_3 and approximately 10 ppmv (7%) oxidation of NO to NO_2. (Note: The catalysts are installed downstream of the ESP where flue gas temperature is less than 350°F.) • Oxidized mercury removal across the FGD system was measured at 97.6%. • Pilot testing should be completed by August 2004.	• Based on early test results, it appears that the use of a fixed-bed oxidation catalyst could be a practical means to enhance mercury capture for lignite-fired plants equipped with a wet FGD system. However, further evaluation is required. • Representativeness: Technique may be sensitive to flue gas chemistry and flue gas control equipment configuration.
					J.K. Spruce	PRB	• Mercury concentration after the baghouse varies from 10 to 13 µg/Nm^3 with approx. 65% to 90% oxidized. Note: Typically oxidation is only approx. 25% with PRB coal. There has been some difficulty in accurately measuring the elemental mercury concentration due to low values between 1 to 3 µg/Nm^3. • Pilot testing began in September 2003 and should be completed in early 2005. • After 8 months, oxidation of elemental mercury across Pd #1 is 94%. • After 7 months, oxidation across Carbon #6 is 91%. • After 7 months, oxidation across SCR is 94%. • After 8 months, oxidation across gold is 92%.	• PRB-fired plants equipped with a baghouse may naturally generate a relatively high proportion of oxidized mercury. • Representativeness: Technique may be sensitive to flue gas chemistry and flue gas control equipment configuration.

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Evaluation of Mercury Speciation at Power Plants Using SCR and SNCR NOx Control Technologies DE-FC26-98FT40321-36 Lynn Brickett	$445,000	UND/EERC The project team includes EPRI and EPA.	4/1/01 - 10/1/03	**Characterization** Field test program will determine the effect NOx SCR and SNCR controls have on the speciation of mercury in the combustion flue gas and resultant enhancement of mercury captured in downstream pollution control equipment.	2001 - 6 plants 2002 - 4 plants	PRB and Bit.	The 2001 field-testing was conducted at six coal-fired power plants. Four of the plants are equipped with SCR controls, one plant uses SNCR control, and one plant uses ammonia and sulfur trioxide for ash conditioning to improve particulate control. Field-testing was repeated in 2002 at two of the 2001 SCR equipped plants and two additional plants with SCRs. Overall test results are as follows: • SNCR and NH_3/SO_3 flue gas conditioning did not affect mercury oxidation. • For the bituminous plants, the increase in oxidized mercury across the SCR varied significantly from 11 to 70 percentage points. The oxidized mercury at the downstream pollution control device (PCD) inlet, increased from -1 to 37 percentage points with an average of 17%. However, for the two sites with minimal SCR oxidation, the non-elemental mercury was greater than 90% both with and without the SCR. • SCR catalyst did not significantly promote the oxidation of mercury for the one PRB test site. The oxidized mercury increased 20 percentage points across the SCR, but was unchanged at the PCD inlet. • SCR catalysts promote mercury capture in wet FGD systems and possibly reduce the re-emission of elemental mercury. For the three plants with SCR and wet FGD, mercury removal was 84 - 92% (average 89%) with SCR operation and 43 - 51% (average 48%) without SCR operation. However, the plants tested used magnesium-lime wet FGD systems and may not be representative of performance on limestone wet FGD systems. • SCR size, as measured by space velocity, appeared to have a minimal affect on mercury oxidation across the SCR. There was no significant difference in non-elemental mercury at the SCR outlet or PCD inlet for the five bituminous plants. • Based on results from the two plants tested in 2001 and 2002, there was little change in mercury oxidation associated with catalyst aging. However, it is uncertain whether additional catalyst aging might affect mercury oxidation. • The increase in oxidized mercury across the SCR at site S2 decreased from 43 percentage points in 2001 to 33 percentage points in 2002. However, there was no change in oxidized mercury at the PCD inlet which remained approx. 97%. The overall mercury removal across the ESP and wet FGD was 84% in 2002 and 89% in 2001. • The increase in oxidized mercury across the SCR at site S4 decreased from 71 percentage points in 2001 to 30 percentage points in 2002. Again however, there was no change in oxidized mercury at the PCD inlet which was 93% in 2001 and 95% in 2002. In 2001, the oxidized mercury level at the air preheater outlet was 87% with SCR and 56% without. In comparison, these values were 96% with SCR and 57% without SCR in 2002. The overall mercury removal across the venturi scrubber was essentially the same in 2002 and 2001: 93% and 90%, respectively. In 2002, mercury capture was 44% without SCR and elemental mercury levels rose from 1.1 to 6.4 $\mu g/Nm^3$. • At site S5, oxidized mercury increased from 44% to 81% across the SCR catalyst and was 95% at the ESP inlet. The overall mercury capture across the ESP and wet FGD was 90% for the unit with SCR. For the unit without SCR, the percentage of oxidized mercury at the ESP inlet was 80%, and the overall mercury capture across the ESP and wet FGD was 51%. An increase in elemental mercury (4.7 to 6.1 $\mu g/Nm^3$) across the wet FGD was observed for the unit without SCR. • Site S6 fires a low-sulfur compliance coal, therefore no wet FGD system for either unit. Oxidized mercury increased from 64% to 83% across the SCR catalyst and was 87% at the ESP inlet. Without SCR, oxidized mercury was 69% at the ESP inlet. The presence of SCR had no apparent effect on mercury removal across the ESP.	• The results from the 2001 and 2002 field-testing are mixed and demonstrate that, while oxidation of mercury across SCR systems can occur, the oxidation is a complex process that may be dependent on several variables such as coal properties, furnace combustion conditions, and SCR catalyst factors including type, sizing, and age. • For site S4, the measured coal chlorine content in 2001 ranged from 350 to 1280 ppm and from 240 to 300 ppm in 2002 although the same mine was used during both years. • Representativeness: The elemental mercury fraction of total mercury was typically higher than ICR elemental mercury fractions for similar configurations without SCR turned on. Only one demonstration site for low rank coal power plant equipped with an SCR.

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Project Title	DOE Funding	Lead Company / Participants	Start/End Dates	Project Description	Plant Site	Coal Rank	Results	Policy Issues
Evaluation of Mercury Control Technologies for Utilities Burning Lignite Coal DE-FC26-98FT40321-45 Lynn Brickett		UND/EERC The project team includes EPRI and several electric utilities that operate lignite-fired plants.		**Alternative sorbents** Conduct a three-year, two-phase project to develop and test sorbent injection mercury control technologies for utilities that burn lignite coal. The first phase of the project, scheduled for 2002-2003, is to conduct bench-scale and pilot-scale evaluation for screening of potential sorbents. Bench-scale testing using a simulated lignite coal flue gas was conducted using several carbon sorbents prepared from three lignite coals, a calcium silicate, and NORIT's DARCO FGD activated carbon. Pilot-scale testing using two lignite coals (Poplar River and Freedom coal mines) was conducted with EERC's 550,000 Btu/hr combustor and four particulate control configurations: 1) ESP, 2) FF, 3) combined ESP & FF, and 4) Advanced Hybrid. The second phase of the project, scheduled for 2004-2005, is to conduct full-scale field tests of the selected sorbents at Saskatchewan Power's Poplar River Power Station that burns lignite and is equipped with an ESP. In addition to testing sorbent performance with an ESP, a 1 to 5 MW pilot-size fabric filter will be tested to simulate operation with a COHPAC configuration.	Poplar River	Lignite	• Bench-scale tests results indicated that the inactivated lignite-based carbon sorbents and calcium silicate were not effective. The lignite-based carbon sorbents activated at 800°C performed significantly better than the same carbon sorbents activated at 750°C. The DARCO FGD and 800°C activated Luscar char-derived sorbents were selected for further pilot-scale testing. Results from the pilot-scale testing are: • The Poplar River coal had a higher mercury concentration than the Freedom coal, but both coals resulted in similar speciation with 85% elemental and 15% oxidized mercury. • Lignite coal requires a higher sorbent feed rate for similar mercury removal compared to full-scale data for bituminous coal. To achieve 70% mercury removal, the best Luscar sorbent injection rates were 17.1, 7.8, and 2.92 lb/MMacf for the ESP, FF, and combined ESP-FF configurations respectively. • Mercury removal was approx. 10-15 percentage points higher for the Freedom coal compared to the Poplar River coal for the ESP-only configuration. • Mercury removal was approx. 10 - 15 percentage points lower for both the Freedom and Poplar River coals when the flue gas temperature was increased from 300° to 400°F for all particulate control configurations. • Increasing sorbent injection rates and lowering gas temperatures improved mercury capture. • Fabric filter material (Gore vs. Ryton) had no effect on mercury capture. • Adding NaCl to coal feeder can enhance sorbent performance. • The relative mercury removal efficiencies for the control device technologies were TOXECON > *Advanced Hybrid* filter > FF > ESP. • Field testing at the Poplar River Power Station is scheduled to begin in Fall 2004.	• Activated carbon injection is not as effective with lignite compared to bituminous coal. • The bench-scale and pilot-scale testing demonstrated the importance of hydrogen chloride in the flue gas, which apparently conditions the sorbents. Further evaluation is required. • Long-term testing is needed to evaluate effects of sorbent injection on plant operations and equipment. • Representativeness: Scale-up of the results from demonstration must be reconciled based on past experience with flue gas control technology of trace species.
Mercury Control with the Advanced ElectroCore Particulate Collector DE-FC26-00NT40757 Peter Botros	$1,191,267	LSR Technologies The project team includes EPRI, EPA, and Alabama Power Company (Southern Company Services).	2/14/00 - 6/30/02	**Novel process** The ElectroCore is an electrically enhanced mechanical separator designed to be retrofitted downstream of an existing ESP to optimize fine particulate collection. The ElectroCore process first pre-charges the ash particles and then uses combined electrical and centrifugal forces to separate the flue gas into "dirty" and "clean" gas streams. The dirty gas stream can either be re-circulated to the inlet of the upstream ESP or diverted to a polishing ESP or FF. The testing was conducted at Alabama Power Company's E.C. Gaston Unit No. 4 that burns bituminous coal.	Gaston	Bit.	The pilot-scale testing was conducted from November 2001 through February 2002. Test results indicate the ElectroCore process captures approximately 90% of the total mercury at a PAC injection rate of 7 lb/MMacf.	• Insufficient test data available to evaluate the mercury capture effectiveness of the ElectroCore technology. Further evaluation is required. • Representativeness: Scale-up of the results from demonstration must be reconciled based on past experience with flue gas control technology of trace species.
In-Situ Sorbent Removal of Mercury: The THIEF Process		NETL In-house	On-going	**Novel process** The THIEF process (U.S. Patent No. 6,521,021) removes mercury from coal combustion flue gas by adsorption/absorption onto thermally activated sorbent produced in-situ. The sorbent consists of semi-combusted coal, which is extracted from the furnace and then injected into the flue gas downstream of the air preheater. The thermally activated sorbent reacts with the mercury and is removed from the flue gas by the downstream particulate control device.	Laboratory pilot test	Bit. & PRB	The in-situ produced sorbent is not as reactive as commercially available activated carbon, but pilot-scale testing indicates that mercury removal efficiencies of up to 70% are achievable.	• Further evaluation is required. • Representativeness: Scale-up of the results from demonstration must be reconciled based on past experience with flue gas control technology of trace species.

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<table>
<tr><th>Project Title</th><th>DOE Funding</th><th>Lead Company / Participants</th><th>Start/End Dates</th><th>Project Description</th><th>Plant Site</th><th>Coal Rank</th><th>Results</th><th>Policy Issues</th></tr>
<tr><td>Photochemical Removal of Mercury: The GP-254 Process</td><td></td><td>NETL In-house</td><td>On-going</td><td><u>Novel process</u>
The GP-254 process (U.S. Patent No. 6,576,092) uses 253.7-nm ultraviolet radiation to induce components of flue gas to react with elemental mercury and subsequently cause an increase in the fraction of oxidized mercury. The oxidized mercury species can then be captured near the radiation zone or in downstream particulate control or wet FGD pollution control equipment.</td><td>Laboratory bench-scale</td><td></td><td>Small-scale laboratory testing using simulated flue gases have been used to demonstrate the process.
The process has been licensed by Powerspan Corporation under the name “Photochemical Oxidation” (PCO). According to Powerspan, preliminary testing of PCO indicates the process is capable of 90% mercury removal. Powerspan plans to conduct pilot-scale testing within the next year.</td><td>• Representativeness: Scale-up of the results from laboratory demonstration must be reconciled based on past experience with flue gas control technology of trace species.</td></tr>
<tr><td>Long-Term Operation of a COHPAC System for Removing Mercury From Coal-Fired Flue Gas

DE-FC26-02NT41591
Andrew O’Palko</td><td>$1,356,976</td><td>ADA-ES

Other participants include Southern Company, Reaction Engineering, Southern Research Institute, Grubb Filtration Testing Services, Hamon Research-Cottrell, EPRI, and several utility company sponsors.</td><td>9/25/02 - 10/26/05</td><td><u>Activated carbon injection</u>
Conduct a one-year long-term performance evaluation of the impact of powdered activated carbon injection on the COHPAC fabric filter particulate collection system at Alabama Power’s 270 MW E.C. Gaston Unit 3 that burns low sulfur bituminous coal and uses a hot-side ESP and COHPAC fabric filter for particulate control. The long-term testing will include six-month PAC injection with the existing COHPAC filter bags and six-month PAC injection with new high-permeation filter bags.</td><td>Gaston</td><td>Bit.</td><td>Preliminary baseline test results include: 1) higher COHPAC cleaning frequency compared to April 2001 Phase I tests, 2) large variation (0 to 90%) in baseline mercury removal, and 3) higher carbon content in COHPAC hopper ash compared to Phase I tests. Based on results of optimization testing, the PAC injection rate was lowered from 1.5 to 0.3 lb/MMacf. Average mercury removal varied from 70 to 95% at 0.3 lbs/MMacf PAC injection rate during May 2003 optimization testing. The following table provides a summary comparison of the April 2001 versus 2003 long-term testing:
<table>
<tr><th>Test Variable</th><th>2001</th><th>July-November 2003</th></tr>
<tr><td>ACI Feed Rate (lbs/MMacf)</td><td>1.5</td><td>0.55</td></tr>
<tr><td>Average Mercury Removal (%)</td><td>78</td><td>86</td></tr>
<tr><td>Variation in Mercury Removal (%)</td><td>36-90</td><td>64-98</td></tr>
<tr><td>Average Cleaning Frequency (p/b/h)*</td><td>1.5</td><td>3.5</td></tr>
<tr><td>Average Baseline LOI (%)</td><td>11</td><td>17</td></tr>
<tr><td>Average Baseline Mercury Removal (%)</td><td>0</td><td>26</td></tr>
<tr><td>Average Baseline Cleaning Frequency (p/b/h)</td><td>< 0.5</td><td>1.8</td></tr>
</table>
* Pulses per bag per hour (p/b/h)</td><td>• Of particular concern during PAC injection is the increased cleaning frequency of the COHPAC which could adversely affect filter bag life.
• Representativeness: The Loss On Ignition (LOI) of the ash, which serves as a measure of unburned carbon was higher in 2003. This resulted in higher baseline values for mercury removal and filter bag cleaning frequency.</td></tr>
<tr><td>Preliminary Field Evaluation of Mercury Control Using Combustion Modifications

DE-FC26-03NT41725
Peter Botros</td><td>$489,600</td><td>GE-EERC

Other participants include Western Kentucky Energy.</td><td>1/23/03 - 7/22/04</td><td><u>Novel process</u>
Conduct a two-year field evaluation using combustion modifications (combination of overfire air (OFA) and coal reburn) to achieve multi-pollutant control of both NOx and mercury. Testing being conducted at Western Kentucky’s RD Green Unit 2 that burns bituminous coal and is equipped with an ESP and wet FGD.</td><td>RD Green</td><td>Bit.</td><td>• Pilot-scale testing with coal reburn achieved over 90% mercury removal at the ESP outlet.
• Mercury removal was approximately 40% at the ESP outlet and 70% at the wet FGD outlet during initial baseline testing conducted in October 2003 without coal reburn.
• Mercury removal remained at approximately 40% at the ESP outlet during coal reburn optimization testing for NOx and LOI emissions in January 2004. (NOx reduced by 70% while maintaining LOI at 2%-3%.)
• Additional testing to be conducted in Fall 2004 to optimize mercury reduction via combustion modifications that will increase LOI to 6%-8%.</td><td>• Combustion modification could provide a multi-pollutant control for NOx and mercury.</td></tr>
<tr><td>Evaluation of Mercury Emissions from Coal-Fired Facilities with SCR-FGD Systems

DE-FC26-02NT41589
Peter Botros</td><td>$584,419</td><td>CONSOL

Other participants include numerous electric utility companies that are providing host sites for the testing.</td><td>9/9/02 - 9/7/05</td><td><u>Characterization</u>
Conduct mercury speciation field-testing at ten bituminous coal-fired power plants equipped with both SCR and FGD systems. The objective of the study is to measure the level of mercury oxidation across the SCR and subsequent removal in the downstream FGD system. The 27-month long program will include testing at five plants equipped with an SCR and wet limestone FGD, three plants with an SCR and wet lime FGD, and two plants with an SCR and dry lime FGD.</td><td>10 plants</td><td>Bit.</td><td>• Four sampling tests were performed on a 684 MW unit at a West Virginia plant in August 2003. The unit consists of plate-type SCR catalysts, a cold-side ESP, and a wet lime FGD. The results show that nearly 90% of the elemental mercury was oxidized across the SCR-air heater combination. On a coal-to-stack basis, total mercury removal was approximately 72%. However, 15% of the flue gas bypasses the FGD scrubber. A mercury removal of 84% was calculated for the FGD system alone.
• Results from the nine other facilities being tested are not currently available.</td><td>• The ability of an SCR to oxidize elemental mercury upstream of the FGD is being observed along with the total mercury removal efficiency of the entire system.
• During previous experiments, CONSOL observed an average mercury removal of 66±8% at six facilities with wet FGDs, but no SCR catalysts.</td></tr>
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Project Title	DOE Funding	Lead Company / Participants	Start/End Dates	Project Description	Plant Site	Coal Rank	Results	Policy Issues
Direct Measurement of Mercury Reactions in Coal Power Plant Plumes DE-FC26-03NT41724 Bill Aljoe	$648,154	EPRI Other participants include UNDEERC, Frontier Geosciences and We Energies.	3/18/03 - 9/17/04	**Characterization** Characterize the speciation of mercury in the stack plume of a coal-fired power plant. Testing conducted at We Energies' Pleasant Prairie Plant. The test will include simultaneous mercury measurements in the stack and stack plume using aircraft instruments. The in-stack and stack plume measurements will be compared to determine whether the speciation of mercury changes as it is transported downwind in the plume. In addition, a plume dilution sampling device is being used in an attempt to simulate the cooling and dilution processes that occur in the stack plume. If results of the plume dilution sampling device are comparable to the stack plume measurements it could be used to estimate the mercury speciation changes for other plants.	Pleasant Prairie	PRB	Field measurement program conducted in August-September 2003. Final report not yet available. Preliminary analysis of data at both Pleasant Prairie and Bowen (see below) suggests that a significant portion of the oxidized mercury emitted from power plant stacks is transformed to elemental mercury very rapidly upon release — between 15 percent to 66 percent of the initial oxidized mercury was converted to elemental mercury at 5 miles downwind.	• If oxidized mercury is reduced to elemental mercury within the stack plume, there should be less concern with local "hot spots" of mercury deposition and perhaps less environmental objections to a mercury emissions trading program.
Evaluation of Mercury Speciation in a Power Plant Plume DE-FC26-98FT40321-54 Bill Aljoe	$27,324	UND/EERC Other participants include EPRI, Frontier Geosciences, TVA and Southern Company.	10/1/02 - 3/31/03	**Characterization** Characterize the speciation of mercury in the stack of a coal-fired power plant to support the concurrent characterization of mercury species in the downwind plume. Testing conducted at Southern Company's Bowen Plant.	Bowen	Bit.	Field measurement program conducted in October 2002. Final report not yet available. See preliminary analysis above for Bowen and Pleasant Prairie.	• See above comment.
Ambient $PM_{2.5}$, Ozone, and Mercury Formation, Transport, and Monitoring Research DE-AI26-98FT40406 Bill Aljoe	$142,000	Tennessee Valley Authority Other participants include EPRI, Frontier Geosciences, UNDEERC, and Southern Company.	10/1/02 - 6/30/03	**Characterization** Characterize the speciation of mercury in the downwind plume of a coal-fired power plant using instrumented aircraft.	Bowen	Bit.	Field measurement program conducted in October 2002. Final report not yet available. See preliminary analysis above for Bowen and Pleasant Prairie.	• See above comment.
Oxidation of Mercury Across SCR Catalysts in Coal-Fired Power Plants Burning Low-Rank Coals DE-FC26-02NT41728 Jose Figueroa	$69,698	Reaction Engineering Other participants include EPRI, Ceramics GmbH, and American Electric Power (AEP).	2/19/03 - 8/18/03	**Characterization** Conduct a six-month-long pilot-scale mercury speciation test for five commercially-available NOx SCR catalysts using a flue gas slipstream. Parametric testing will evaluate the effect of space velocity (residence time) and ammonia feed rate on mercury oxidation across the SCR catalysts. Testing conducted at AEP's 1300 MW Rockport Power Plant Unit 1 that burns a subbituminous Powder River Basin coal.	Rockport	PRB	Preliminary results from the initial mercury speciation testing are under review. Some general observations from the S-CEM measurements are: 1) mercury oxidation ranged from approx. 0% to 50% across the five catalysts at a space velocity of 5,700 hr^{-1}, 2) mercury oxidation increased to 60% to 80% without ammonia feed, 3) an unexplained 10% to 40% reduction of total mercury was measured across the catalysts, 4) mercury oxidation decreases as space velocity increases. To study the degradation of catalyst activity, the experiment was broken down into two weeklong sampling periods. The first test series took place at the outset of the six-month project (March 28 - April 2, 2003), and this data represents fresh catalyst activity with only 300 hours of previous operation. The second sampling campaign (August 7-16, 2003) was carried out after the catalysts had experienced 2,200 hours of continuous operation. Fresh catalysts (300 hours) produced 25-70% mercury oxidation at typical full-scale space velocities, which is consistent with full-scale oxidation results observed for bituminous coal flue gas. In comparison, the aged catalysts (2,200 hours) oxidized only 0-42% of the elemental mercury. Consistent with full-scale measurements, all catalysts exhibited higher mercury oxidation without ammonia. This project is scheduled to continue through September 2004.	• Mercury oxidation can vary significantly across NOx SCR catalysts in PRB coal applications. Further evaluation is required. • Representativeness: Relatively high chlorine content (100-240 ppm on a dry basis) was observed for the PRB coal blend at Rockport. This resulted in mercury oxidation levels normally observed with bituminous coal.

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Project Title	DOE Funding	Lead Company / Participants	Start/End Dates	Project Description	Plant Site	Coal Rank	Results	Policy Issues
Mercury and Air Toxics Element Impacts of Coal Combustion Byproduct Disposal and Utilization DE-FC26-03NT41727 Nam Lee	$1,200,000	UND/EERC	1/23/03 - 1/22/06	**Characterization** Evaluation of the potential release of mercury and other air toxic elements associated with the disposal and commercial use of coal utilization by-products. Laboratory and field-testing will be conducted on various ash and FGD CUBs from conventional and advanced pollution control systems. The potential release mechanisms to be evaluated include leaching, vaporization at ambient and elevated temperature, and biologically induced releases.	Various	Bit. PRB Lignite	The three-year project will be completed by December 2005. Results not available.	• Results from this testing will be critical in determination of the cost of disposal for CUBs associated with mercury control technologies.
Evaluation of the Emission, Transport, and Deposition of Mercury, Arsenic, and Fine Particulate Matter from Coal Based Power Plants in the Ohio River Valley Region DE-FC26-03NT41723 Bill Aljoe	$1.260,777	Ohio University Other participants include Consol Energy, Advanced Technology Systems Inc., and Atmospheric and Environmental Research Inc.	4/03/03 - 7/02/05	**Characterization** Quantitatively evaluate, via ambient measurements and numerical modeling, the emission, transport, and deposition of mercury and air toxics in the Ohio River Valley region, focusing on the impact of mercury emissions from coal power plants in the region.	N/A	N/A	Ambient monitoring program began in March 2003. Baseline chemical transport model simulations have been completed. Mercury emissions inventory data have been updated and meteorological simulations have been completed in preparation for short term model runs.	• This project will improve the current level of understanding of the fate and distribution of mercury emitted by coal power plants over a regional scale. The model will allow key stakeholders to investigate specific scenarios concerning individual or collective changes in power plant emissions of mercury in the Ohio River Valley region
Catalyst Additives to Enhance Mercury Oxidation and Capture DE-PS26-02NT41900 Bruce Lani	$300,000	Southern Research Institute Other participants include Niksa Energy Associates and Reaction Engineering	10/1/03 – 5/31/05	**Characterization** The objective of this project is to investigate the enhancement of elemental mercury oxidation through testing various catalyst materials and different catalysis implementation processes, including duct injection of catalyst/sorbent hybrids, coated low-pressure drop screens, and fundamental mechanisms associated with enhanced mercury oxidation on SCR catalysts. Testing will be conducted using SRI's 1.75 MW (6.0 million Btu/hr) pilot-scale combustor.	N/A	Bit. & PRB	Test matrix under development. Results not available	• Results will be used to develop and improve models to predict mercury speciation in full-scale boilers burning subbituminous and bituminous coals.
Fate of Mercury in Synthetic Gypsum Used for Wallboard Production DE-FC26-04NT42080 Chuck Miller	$258,977	USG Corporation Other participants include EPRI.	4/1/04 – 3/31/06	**Characterization** Determine fate of mercury in byproduct gypsum produced via flue gas desulfurization (FGD) systems at coal-fired power plants when that gypsum is used to produce wallboard in commercial manufacturing facilities, including the susceptibility of mercury to leaching into groundwater when the wallboard is placed into landfills at the end of its life cycle.	N/A	N/A	Results not available. Testing should be complete by September 2005.	• Results from this testing will be critical in determination of continued utilization of wet FGD gypsum for wallboard manufacture.

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Project Title	DOE Funding	Lead Company / Participants	Start/End Dates	Project Description	Plant Site	Coal Rank	Results	Policy Issues
Pilot and Full-Scale Demonstration of Advanced Mercury Control Technologies for Lignite-Fired Power Plants DE-FC26-03NT41897 Andrew O'Palko	$700,000	UNDEERC	6/30/03 – 12/31/04	**Sorbents & oxidation additives** Develop advanced innovative mercury control technologies to reduce mercury emissions from North Dakota lignite-fired power plants. Testing will determine the feasibility of the following technologies: Hg oxidation for increased Hg capture in wet and dry scrubbers, incorporation of additives and technologies that enhance Hg sorbent effectiveness in electrostatic precipitators and baghouses, use of amended silicates in lignite-derived flue gases for Hg capture, and use of Hg adsorbents within a baghouse. Testing will be conducted using UNDEERC's 550,000 Btu/hr pilot-scale combustor and slipstream and field testing at power plants. (Note: This task originally included pilot-scale field testing to evaluate the mercury control performance of a new technology that utilizes secondary adsorbent filter cartridges installed within the existing filter bag units of a pulse-jet baghouse. The adsorbent filter was developed by W. L. Gore & Associates with funding by U.S. EPA. The technology is unique because it does not rely on continuous sorbent injection. However, W.L. Gore decided to suspend development work on the technology.)	Various	North Dakota Lignite	Task 3.1 – Impacts of co-firing tire-derived fuels. Field testing was completed at the Heskett Station in April 2004. Results not available. Task 5 – Field testing of sorbents. Slipstream baghouse testing was completed at the Leland Olds Station in May 2004. Results not available.	• Power plants firing North Dakota lignite produce flue gases that contain high levels of elemental mercury that is difficult to capture using commercially available activated carbon sorbents. Results will identify advanced mercury control technology options for plants burning North Dakota lignite.
Mercury Control Technologies for Electric Utilities Burning Subbituminous Coal DE-FC26-98FT40321-73 Lynn Brickett	$262,740 (est.)	UNDEERC Other participants include several electric generation companies, coal companies, Babcock Power, B&W, EPRI, Kinectrics, and WRI	1/1/04 – 12/31/04	**Sorbents, coal blending, & oxidation additives** Conduct pilot-scale testing of various mercury control technologies for plants burning subbituminous coal. Testing includes mercury oxidation agents, carbon and non-carbon sorbents, sorbent enhancement agents, blending of subbituminous and bituminous coals. The pilot-scale testing include evaluations using an ESP only, ESP and baghouse, and a spray dryer FGD with an ESP or baghouse.	N/A	PRB	Testing in-progress. Preliminary results indicate baseline mercury capture for ESP and SDA configurations of approx. 10%. Untreated activated carbon injection (NORIT FGD) at 8 lb/MMacf achieved approx. 50% mercury capture. However, use of oxidation additives with activated carbon injection significantly reduced the required sorbent feed rate (2.4 to 4 lb/MMacf) to achieve 50% mercury capture.	• Power plants firing subbituminous coal produce flue gases that can contain high levels of elemental mercury that is difficult to capture using commercially available activated carbon sorbents. Results will identify advanced mercury control technology options for plants burning subbituminous coal.
Evaluation of Sorbent Injection for Mercury Control DE-FC26-03NT41986 Andrew O'Palko	$6,000,000	ADA Environmental Solutions Other participants include Alstom Power, EPRI, Western Fuels Association, and Norit Americas.	9/30/03 – 9/29/06	**Sorbent injection** Evaluate injection of activated carbon and other sorbents to remove mercury for a variety of coal and air pollution control equipment configurations. Testing will be conducted at four power plants: (1) Sunflower Electric's Holcomb Station that burns a blend of subbituminous Powder River Basin (PRB) and bituminous coal and is equipped with a spray dryer absorber and fabric filter baghouse (SDA/FF); (2) Ontario Power's Nanticoke Station that burns a blend of PRB and bituminous coal and is equipped with an electrostatic precipitator (ESP); AmerenUE's Meramec Station that burns PRB coal and is equipped with an ESP; and (4) American Electric Power's (AEP) Conesville Station that burns bituminous coal and is equipped with an ESP and wet flue gas desulfurization (FGD) system.	Holcomb	PRB/Bit	Baseline and parametric testing conducted April – June 2004. Long-term testing to begin July 2004. Preliminary results indicate bituminous coal blending improves Hg oxidation and capture.	• Additional field-testing of commercially available activated carbon sorbent is required to determine mercury capture performance across the full range of power plant air pollution control device configurations and coal ranks.
					Nanticoke	PRB/Bit	Testing scheduled to begin August 2005.	• See above
					Meramec	PRB	Testing scheduled to begin August 2004.	• See above
					Conesville	Bit.	Testing scheduled to begin March 2005.	• See above
Demonstration of Amended Silicates for Mercury Control DE-FC26-03NT41988 Andrew O'Palko	$900,000	Amended Silicates, LLC Other participants include the University of North Dakota Energy and Environmental Research Center, Western Kentucky University, and Boral Materials Technologies.	2/24/04 – 8/23/05	**Alternative sorbent** Test a new non-carbon sorbent, Amended Silicates™, which could provide cost effective mercury capture while avoiding adverse impacts on fly ash sales. Testing will be conducted at Cinergy's 175 MW Miami Fort Unit 6, which burns bituminous coal and is equipped with an ESP.	Miami Fort	Bit.	Testing scheduled to begin March 2005.	• A non-carbon sorbent could provide cost effective mercury capture while avoiding adverse impacts on fly ash sales.

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Mercury Control Technology R&D Project Summary

Project Title	DOE Funding	Lead Company / Participants	Start/End Dates	Project Description	Plant Site	Coal Rank	Results	Policy Issues
Sorbent Injection for Small ESP Mercury Control in Low Sulfur Eastern Bituminous Coal Flue Gas DE-FC26-03NT41987 Dawn Chapman	$858,004	URS Group Other participants include ADA-ES and EPRI.	9/26/03 – 9/30/05	**Sorbent injection** Test sorbent injection technology upstream of a small collection area ESP. Testing will be conducted at Southern Company's Plant Yates Unit 1 & 2 that burn bituminous coal. Unit 1 is equipped with an ESP and wet FGD and Unit 2 is equipped with an ESP that utilizes ammonia and sulfur trioxide flue gas conditioning.	Yates	Bit.	Baseline and parametric testing completed in Spring 2004. Based on preliminary results, baseline mercury removal was approx. 35% on Units 1 & 2. Mercury removal increased to approx. 60 to 70% with sorbent injection. However, there was a significant increase in ESP sparking at higher sorbent injection feed rates. Long-term sorbent injection testing is scheduled to begin in Fall 2004.	• Previous full-scale sorbent injection tests have involved relatively large ESPs, but more than 60 percent of the industry is equipped with ESPs having small size collection areas. Any adverse impact of sorbent injection on ESP performance could limit mercury capture.
Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems Phase II DE-FC26-03NT41992 Bruce Lani	$1,385,185	URS Group Other participants include EPRI.	1/1/04 – 8/31/06	**Oxidation catalyst** Conduct pilot-scale testing of fixed-bed catalysts to oxidize elemental mercury in order to increase overall mercury capture in downstream wet FGD systems. Four catalyst materials are scheduled to be tested including: palladium, titanium/vanadium, gold, and carbon. Testing will be conducted at two plants: (1) TXU's Monticello Station Unit 3 that burns Texas lignite and is equipped with an ESP and wet FGD; and (2) Duke Energy's Marshall Station that burns low-sulfur bituminous coal and is equipped with an ESP. The testing includes integration of the oxidation catalyst test chamber with a new pilot-scale wet FGD absorber to allow determination of the removal efficiency across a wet FGD system of mercury oxidized by up to four different catalysts. The FGD absorber will be operated intermittently under lime/natural oxidation and limestone/forced oxidation conditions. The pilot-scale catalyst tests will continue for approximately 14 months at each site.	Monticello	Texas Lignite	Testing scheduled to begin in Fall 2004.	• This project will test catalysts previously identified as being effective in pilot-scale testing (DE-FC26-01NT41185). The use of a fixed-bed oxidation catalyst could be a practical means to enhance mercury capture for lignite-fired plants equipped with a wet FGD system. However, further evaluation is required.
					Marshall	Bit.	Testing scheduled to begin in Spring 2005. Baseline testing conducted at Marshall in Spring 2004 indicates approx. 90% oxidized mercury downstream of ESP. Therefore, another site with lower baseline oxidized mercury is being sought for the evaluation.	• Bituminous coal-fired plants equipped with wet FGD, but no NOx SCR, and with high elemental mercury levels could also benefit from a fixed bed oxidation catalyst.
Evaluation of MerCAP for Power Plant Mercury Control DE-FC26-03NT41993 Bill Aljoe	$1,113,216	URS Group Other participants include Apogee Scientific, EPRI, ADA-ES, North Dakota Industrial Commission (NDIC), CT&E, and Rocky Mountain Laboratories	11/1/03 – 9/30/06	**Novel process** Test EPRI's Mercury Control via Adsorption Process (MerCAP ™) technology. The process involves placing a regenerable, fixed-structure gold sorbent into the flue gas stream downstream of dry or wet FGD scrubbers to capture mercury. Testing will be conducted at Great River Energy's lignite-fired Stanton Station Unit 10 that is equipped with a spray dryer-baghouse and at Southern Company's bituminous-fired Plant Yates Unit 1 that is equipped with an ESP and wet FGD. At Stanton Unit 10, MerCAP sorbent structures will be retrofitted into a single compartment of the fabric filter baghouse equivalent to a 6 MW demonstration. At Plant Yates Unit 1, MerCAP sorbent structures will be configured as a mist eliminator located downstream of a 1 MW pilot-scale wet FGD absorber. Additional tests are proposed to determine the ability to repeatedly thermally regenerate exposed gold MerCAP plates in a 40-acfm test probe.	Stanton	North Dakota Lignite	Baseline testing and installation of infrastructure for MerCAP technology was begun in June 2004. Intensive testing and sampling will occur in July 2004; long–term testing scheduled to begin in August 2004 and be completed in January 2005.	• The results of this study will provide data required for assessing the feasibility and estimating the costs of a full-scale MerCAP process for flue gas mercury removal. It will provide information about optimal operating conditions for different flue gas conditions, the effectiveness of sorbent regeneration, and the ability of the gold sorbent to hold up to flue gas over an extended period. In addition, if successful, the novel approach of incorporating MerCAP structures in existing baghouse compartments will demonstrate a cost-effective means for achieving mercury control using existing baghouse technologies.
					Yates	Bit.	Testing scheduled to begin in Spring 2005.	• See above.
Enhancing Carbon Reactivity in Mercury Control in Lignite-Fired Systems DE-FC26-03NT41989 Lynn Brickett	$1,910,443	UNDEERC Other participants include URS Group, ADA-ES, Babcock & Wilcox (B&W), EPRI, NDIC, and the Lignite Consortium.	10/1/03 – 9/29/06	**Alternative sorbents & oxidation additives** Test enhancements to activated carbon sorbent injection to increase mercury capture for plants burning low-rank lignite coals. Lignite produces higher levels of elemental mercury, which is more difficult to remove. Two different technology approaches will be evaluated: (1) injection of chlorine-based additives in conjunction with activated carbon sorbents, and (2) injection of chemically treated activated carbon sorbents. The first approach will be tested at Basin Electric's 210 MW Leland Olds Station Unit 1 and the 440 MW	Leland Olds 1	North Dakota Lignite	Long-term testing conducted April - May 2004. Preliminary results from parametric testing indicate approx. 55 to 70% mercury control using a chlorine additive (equivalent to 500 ppm Cl in coal) and activated carbon sorbent (approx. 3 lb/MMacf).	• Power plants firing North Dakota lignite produce flue gases that contain high levels of elemental mercury that is difficult to capture using commercially available activated carbon sorbents. Results will identify advanced mercury control technology options for plants burning North Dakota lignite.
					Stanton 10	North Dakota Lignite	Baseline and parametric testing conducted March – May 2004. Preliminary results indicate less than 20% baseline mercury removal across the SDA/BH. Two chemically treated sorbents achieved approx. 90% mercury removal at feed rates of less than 3 lb/MMacf during parametric testing. Long-term testing is on-hold pending completion of a non-project related test burn of PRB coal.	• See above

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				Antelope Valley Station Unit 1. The second approach will be tested at Great River Energy's 140 MW Stanton Station Unit 1 and the 60 MW Stanton Station Unit 10.	Antelope Valley 1	North Dakota Lignite	Testing scheduled to begin in Spring 2005.	• See above
					Stanton 1	North Dakota Lignite	Testing scheduled to begin in Fall 2004.	• See above
Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities - Oxidation Systems for Wet FGD DE-FC26-03NT41991 Andrew O'Palko	$1,602,195	UNDEERC Other participants include URS Group, ADA-ES, B&W, EPRI, NDIC, and the Lignite Consortium.	9/26/03 – 9/25/06	**Oxidation additive** Test the effectiveness of using chlorine-based additives without supplemental sorbent injection to increase mercury oxidation and therefore enhance mercury capture at lignite-fired plants equipped with an ESP and wet FGD. Testing will be conducted at Minnkota Power Cooperative's Milton R. Young Unit 2 that burns North Dakota lignite and TXU's Monticello Unit 3 that burns Texas lignite.	Milton Young 2	North Dakota Lignite	Testing scheduled to begin in Summer 2005.	• Power plants firing lignite coal produce flue gases that contain high levels of elemental mercury that is not captured by wet FGD systems. Increasing mercury oxidation upstream of the wet FGD should result in improved mercury capture.
					Monticello 3	Texas Lignite	Testing scheduled to begin in Summer 2005.	• See above
Advanced Utility Mercury Sorbent Field-Testing Program DE-FC26-03NT41990 Lynn Brickett	$3,000,000	Sorbent Technologies Corporation Other participants include Fuel Tech, Western Kentucky University's Combustion Laboratory, PS Analytical, Spectra Gases, and Stock Equipment Company.	9/29/03 – 9/30/05	**Alternative sorbent** Test advanced halogenated (bromine) activated carbon sorbents that can be used as a cost effective alternative to commercial activated carbon injection for mercury capture. STC will test various sorbent formulations for both hot-side and cold-side ESP applications. A short-term trial of halogenated sorbents was conducted at Duke Energy's Cliffside Plant that is equipped with a hot-side ESP. Longer-term testing will be conducted at Duke Energy's 140 MW Buck Plant that is equipped with a hot-side ESP and burns low-sulfur bituminous coal and at Detroit Edison's 80 MW St. Clair Station that burns a blend of PRB and bituminous coal and is equipped with a cold-side ESP.	Buck	Bit.	Testing scheduled to begin in first quarter 2005.	• Commercially available activated carbon sorbents are not effective for mercury capture in hot-side ESP applications. STC's halogenated sorbent may be a viable mercury control in this application based on preliminary testing conducted at Duke's Cliffside Plant in September 2003.
					St. Clair	PRB/Bit.	Testing scheduled to begin in third quarter 2004.	• Commercially available activated carbon sorbents are not effective for mercury capture at plants burning subbituminous or lignite coals, which have high levels of elemental mercury. STC's halogenated sorbent may be a viable mercury control for these applications in lieu of using a separate oxidation additive.